Saudi Journal of Biological Sciences (2017) **24**, 421–429

King Saud University

Saudi Journal of Biological Sciences

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Characterization of spatial variability of soil physicochemical properties and its impact on Rhodes grass productivity

E. Tola [a,*], K.A. Al-Gaadi [a,b], R. Madugundu [a], A.M. Zeyada [a], A.G. Kayad [b], C.M. Biradar [c]

[a] *Precision Agriculture Research Chair, King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia*
[b] *Department of Agricultural Engineering, College of Food and Agriculture Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia*
[c] *International Center for Agricultural Research in the Dry Areas (ICARDA), Bldg no. 15, Khalid Abu Dalbouh St. Abdoun, P.O. Box 950764, Code No. 11195 Amman, Jordan*

Received 3 February 2016; revised 31 March 2016; accepted 19 April 2016
Available online 27 April 2016

KEYWORDS

Precision agriculture;
Soil properties;
Geospatial analysis;
Productivity;
Rhodes grass

Abstract Characterization of soil properties is a key step in understanding the source of spatial variability in the productivity across agricultural fields. A study on a 16 ha field located in the eastern region of Saudi Arabia was undertaken to investigate the spatial variability of selected soil properties, such as soil compaction 'SC', electrical conductivity 'EC', pH (acidity or alkalinity of soil) and soil texture and its impact on the productivity of Rhodes grass (*Chloris gayana L.*). The productivity of Rhodes grass was investigated using the Cumulative Normalized Difference Vegetation Index (CNDVI), which was determined from Landsat-8 (OLI) images. The statistical analysis showed high spatial variability across the experimental field based on SC, clay and silt; indicated by values of the coefficient of variation (CV) of 22.08%, 21.89% and 21.02%, respectively. However, low to very low variability was observed for soil EC, sand and pH; with CV values of 13.94%, 7.20% and 0.53%, respectively. Results of the CNDVI of two successive harvests showed a relatively similar trend of Rhodes grass productivity across the experimental area ($r = 0.74$, $p = 0.0001$). Soil physicochemical layers of a considerable spatial variability (SC, clay, silt and EC) were utilized to delineate the experimental field into three management zones (MZ-1, MZ-2 and MZ-3); which covered 30.23%, 33.85% and 35.92% of the total area, respectively. The results of CNDVI indicated that the MZ-1 was the most productive zone, as its major

* Corresponding author: Mobile: +966 558759697, tel.: +966 11 4691904 (Office).
E-mail addresses: etola@ksu.edu.sa, elkamiltola@gmail.com (E. Tola), kgaadi@ksu.edu.sa (K.A. Al-Gaadi), rmadugundu@ksu.edu.sa (R. Madugundu), azeida.c@ksu.edu.sa (A.M. Zeyada), akaiad@ksu.edu.sa (A.G. Kayad), c.biradar@cgiar.org (C.M. Biradar).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sjbs.2016.04.013
1319-562X © 2016 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University.
This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

areas of 50.28% and 45.09% were occupied by the highest CNDVI classes of 0.97–1.08 and 4.26–4.72, for the first and second harvests, respectively.

© 2016 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Farming systems have various types of soils, habitats, microclimatic features, and crop varieties, which result in wide variations in soil fertility, water retention and crop productivity (Sciarretta and Trematerra, 2014). Crop yield variability can be caused by many factors, including spatial variability of soil type, landscape position, crop history, soil physical and chemical properties and nutrient availability (Wibawa et al., 1993). Understanding the spatial variability of soil physicochemical characteristics, in both its static (e.g. texture and mineralogy) and dynamic (e.g. water content, compaction, electrical conductivity and carbon content) forms is necessary for site-specific management of agricultural practices, as it is directly contributing to variability in crop yields and quality (Jabro et al., 2010; Silva Cruz et al., 2011). Site-specific practices could help significantly in managing the spatial variability in the productivity of agricultural soils by tailoring the agricultural inputs to fit the spatial requirements of soil and crop (Fraisse et al., 1999). Spatial variations of soil properties across agricultural fields have been reported by many scientists as a major source of variability in crop yields (Gaston et al., 2001). Therefore, determination of the major sources of variation in productivity is a key parameter in achieving efficient site-specific management practices (Mzuku et al., 2005). Variability in agricultural soils is a function of both soil structure and the imposed management practices for crop production (Hulugalle et al., 1997).

Soil Physicochemical properties that are important in crop production are characterized as those that directly affect crop growth, such as water, oxygen, temperature and soil resistance, and others, such as bulk density, texture, aggregation and pore size distribution, that indirectly affect crop growth (Letey, 1995). Soil compaction risk occurs when soil density reaches a critical value, beyond which soil performance is affected considerably. Such critical soil densities are different for different crops in different soils and different climatic regions (Bouma, 2012). Soil compaction negatively affects essential soil properties and functions, such as hydraulic properties and gas-phase transport or root growth; hence, it is associated with various environmental and agronomic problems, such as erosion, leaching of agrochemicals to water bodies, emissions of greenhouse gases and crop yield losses (Keller and Lamandé, 2012). The susceptibility of agricultural soils to soil compaction depends mainly on soil type and moisture status. In general, for moist soils, soil compaction increases with the decrease in soil particle size (Sutherland, 2003).

Spectral vegetation indices are being successfully used as effective measures of vegetation activity and are considered as useful parameters to characterize differences in crop canopy characteristics; hence, for the assessment of spatial variability in agricultural fields (Al-Gaadi et al., 2014; Henik, 2012). The Normalized Difference Vegetation Index (NDVI) is considered by many scientists and researchers as one of the most important vegetation indices utilized for the prediction of crop production, because of its strong relationship with crop yield (Yin et al., 2012; Bhunia and Shit, 2013; Matinfar, 2013; Sheffield and Morse-McNabb, 2015).

Geostatistical methods are essential for the investigation of spatial variations of soil and crop parameters across agricultural fields, which can lead to the efficient implementation of site-specific management systems (Najafian et al., 2012). An experimental variogram is usually used to measure the average degree of dissimilarity between locations that are not sampled and nearby data values (Deutsch and Journel, 1998). Hence, correlations at various distances can be established to come up with values for non-sampled field locations.

Soil parameters are the most important factors in crop production systems. Hence, understanding their spatial variability across agricultural fields is essential in optimizing the application of agricultural inputs and crop yield. Therefore, the objectives of this study were: (i) to characterize the spatial variability of selected soil physicochemical properties across an agricultural field, and (ii) to investigate the spatial correlation between the studied soil properties and CNDVI as an indicator of Rhodes grass productivity.

2. Materials and methods

2.1. Experimental site

The study was conducted on a 16 ha field irrigated by a center pivot system in a commercial farm located in the eastern region of Saudi Arabia that extended between the latitudes of 23° 48′ 46.85″ and 24° 14′ 22.65″ N and the longitudes of 48° 49′ 48.98″ and 49° 20′ 55.45″ E (Fig. 1). The farm was laid out along a valley area with small undulations under an arid climatic zone. The study area experienced hot summers with mean temperature of 42 °C and cold to moderate winter with a mean temperature of 18 °C. The mean annual rainfall was in the range from 60 to 90 mm. The major crops cultivated in the experimental farm include potatoes, wheat, alfalfa, corn, Rhodes grass and Sudanese grass.

2.2. Sampling strategy

The field was sampled on a 40 m × 40 m grid strategy described by Mallarino and Wittry (2001) and Franzen (2011). This sampling strategy resulted in 96 sampling locations (field data points) covering the whole experimental field (Fig. 2). Of the 96 sampling locations of the experimental field, data of 86 sampling points within the actual experimental area were used for this study. The preparation of the sampling grid map was generated using ArcGIS (Ver. 2010) software program, while a GPS-receiver was used for locating the predetermined sample points in the field, for the collection of soil samples in the period from 10 to 15 April, 2013.

Download English Version:

https://daneshyari.com/en/article/5745642

Download Persian Version:

https://daneshyari.com/article/5745642

Daneshyari.com